State of California
The Resources Agency
DEPARTMENT OF WATER RESOURCES
Division of Planning and Local Assistance
San Joaquin District

CROP WATER USE

A Guide for Scheduling Irrigations in the Southern San Joaquin Valley

1992 − 1996

District Report

March 2004

Arnold Schwarzenegger
Governor
State of California

Michael Chrisman
Secretary for Resources
The Resources Agency

Lester A. Snow
Director
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FOREWORD

This report summarizes estimates of crop water use calculated by DWR and provided to cooperating farm advisors in the three southern counties of the San Joaquin Valley from 1992 through 1996. Farm advisors disseminated this information within their counties to guide growers in scheduling irrigations for eight major crops representing about 85 percent of the irrigated land in the area. Rational irrigation scheduling – applying irrigation water at the right times and in the right amounts – contributes to both optimizing crop production and conserving the dwindling irrigation supplies in the area.

This report is divided into three major sections: (1) a description of the methods used in obtaining data, calculating crop water use estimates, and transmitting those estimates to growers in the southern San Joaquin Valley, (2) a brief discussion of each year's general climatic conditions and the effects upon pan evaporation and crop evapotranspiration, and (3) weekly and monthly summaries of calculated crop water use for all crops each year and for each crop for all years.

Based upon DWR's evaluation and historical comparisons, the crop water use estimates were judged to be sufficiently reliable for scheduling crop irrigations.

Paula J. Landis, Chief
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Crop water use estimates for 1992 to 1994 were calculated by David L. Scruggs, Senior Land and Water Use Scientist, San Joaquin District. Estimates for 1994 to 1996 were calculated by Kent E. Frame, Land and Water Use Scientist, San Joaquin District, Department of Water Resources.

INTRODUCTION

Agricultural scientists have long recognized the benefits derived from matching irrigation applications to crop water needs. Research results defining the interrelationships between various irrigation treatments, fertility levels, and crop yields are available for most California crops.

Careful irrigation scheduling – applying water at the proper times and in the correct amounts – contributes to optimum crop production, as well as on-farm water and energy conservation. Grower interest in rational methods for scheduling irrigations has increased greatly during this period, as economic factors and water shortages have increased growers' awareness of the benefits attainable through careful irrigation management.

Crop water use data, though of use to all growers, is particularly valuable to those who manage water with the more sophisticated irrigation methods such as sub-surface and surface drip systems, low volume micro sprinklers, solid set sprinklers, hand-moved sprinklers, and linear move sprinklers.

According to the California Department of Food and Agriculture, in 1996 the four counties of Kern, Kings, Tulare, and Fresno produced $9.1 billion (37 percent) of the $24 billion total California farm revenue. Statewide, the California Farm Bureau estimates that between 1976 and 1995, applied agricultural water decreased 2.5 percent while crop acreage increased 8 percent and crop production increased 67 percent. The Department of Water Resources' Bulletin 160-98 projects a continued decrease in applied agricultural water from 1995 to 2020. DWR's services, programs, and data, such as *Crop Water Use* reports and the California Irrigation Management Information System (CIMIS), help growers and others reduce applied water while enhancing production.

These efforts, continued through 1996 in the southern San Joaquin Valley, are described and summarized in this report. Procedures for collecting data and producing the *Crop Water Use* report are described on the following pages.

This report is an update of DWR's *Crop Water Use – A Guide for Scheduling Irrigations in the Southern San Joaquin Valley, 1977 – 1991*. It summarizes estimates of weekly and monthly crop water use calculated by DWR, and provided to cooperating farm advisors in southern counties of the San Joaquin Valley from 1977 to 1991. Evaporation summaries (Ep) and estimated crop water use or evapotranspiration (ET) are included in the tables in Appendices A through D.

The University of California's Cooperative Extension Service and DWR have distributed *Crop Water Use* reports each year since 1977. Farm advisors disseminated this information within their counties to guide growers in scheduling irrigation for eight major crops, representing about 85 percent of the irrigated land in the area.

DATA COLLECTION AND DISSEMINATION

This *Crop Water Use* report was prepared using the following steps:

1. Observing and collecting data from various DWR and U.S. Department of Agriculture agroclimatic sites within the region (see Figure 13).

2. Calculating current crop daily ET rates for specific crops, and daily potential ET-grass and ET-potential (ETP)-alfalfa rates for large geographic areas.[1]

3. Disseminating the collected and calculated data.

The first step included collecting data from established agroclimatic stations and, when necessary, establishing new stations (see Figure 13). Stations are maintained and standardized to specific site criteria as established by the American Society of Agricultural Engineers (ASAE).

The agroclimatic stations are visited weekly and on the first day of each month. Instruments at these stations include: a U.S. Weather Bureau "class A" evaporation pan, a precipitation gauge, a hygrothermagraph, minimum and maximum thermometers, modified atmometers, and an anemometer. The evaporation pan and other agroclimatic instrument readings are scrutinized for accuracy. The Ep may be adjusted during periods of high winds or dry conditions, which represent non-standard conditions.

Next, the qualified station data is used to calculate estimates of current crop ET rates. The observed pan evaporation was multiplied by a specific crop coefficient (Kp), for a specific week, to estimate a crop's ET. This estimate of the previous week's crops ET was reported along with an estimate of the following weeks expected normal water demand. Ep gave a general appraisal of variations in ET demands and, when used with proper coefficients, provided a basis for estimating crop ET basin wide.

After the estimates were calculated, a table was created using the weekly-calculated crop ET and Ep estimates. It was then disseminated to various entities that made the information available to the public through the use of newspapers, the University of California Cooperative Extension, irrigation consultants, and growers.

One important product of this activity was the growers' increased awareness of benefits gained from proper irrigation management. This awareness has resulted in ever-increasing opportunities for private agricultural consultants, water agencies, and county agencies to help growers

[1] Potential ET-alfalfa ETP is the ET rate of vigorously growing alfalfa at 100 percent ground cover and with no moisture stress. ETP is usually calculated from meteorological data. ET rates for specific crops, at specific stages of development, may be estimated from ETP and the predetermined relationship between crop ET and ETP. Potential ET – grass PET is the ET rate of vigorously growing grass at 100 percent ground cover and with no moisture stress.

maintain soil moisture budgets or monitor soil moisture to forecast irrigation dates and amounts of water to be applied to specific crops and fields. The focus of ET data dissemination for the weekly reports was the southern region, primarily Kern, Kings, and Tulare Counties.

Description of Monitoring Sites

The weekly reports include data collected from the following agroclimatic sites: Bakersfield 12S, Lamont 2N, or Bakersfield 14W. All sites were on well-irrigated pastures adhering to standards established by the ASAE. The name denotes the closest town, the number shows the distance, and the capital letter denotes the direction from that town (see Figure 13).

There is a USDA Cotton Field Station evaporation pan near the town of Shafter in Kern County. It was not used in determining Ep rates, but was a tool in judging week to week Ep for reasonableness for use in calculating crop ET. The Cotton Station site is often subjected to changes in the surrounding land use. Consequently, its normal observed Ep is historically approximately 11 percent higher than the long-term normal observed Ep at the other southern San Joaquin/Kern County pan sites.

Another evaporation pan at Fresno State University was used to characterize the evaporative demand in the central San Joaquin Valley. This agroclimatic site is located at the University on an irrigated pasture. It is utilized for comparisons and correlation when necessary to estimate Bakersfield Ep. Based on long-term historical relationships, Bakersfield Ep measures approximately 5 percent less than Ep measured at the Fresno State University pasture.

Description of Weekly Report

Each weekly report includes observed Ep and calculated ET rates for several crops. These crops are potential ET (PET) of grass, ETP of alfalfa, alfalfa hay, cotton, citrus, deciduous orchard (clean cultivated), deciduous orchard (with a cover crop), dry beans, small grains, and vineyard.

These eight different crops represent a significant proportion of the total acreage farmed in the Valley. For example, DWR’s Statewide Planning Branch estimated that in Kern County between 1992 – 1996 these crops, on average, represented 85.2 percent of the total net acreage farmed (Table 1).

Weekly 1992 – 1996 observed and calculated values by crop are summarized in Appendices A-2 to A-6 and C-2 to C-11, and the monthly values in Tables 2 to 6. Individualized data is summarized in Appendices C and D for the years 1992 to 1996 as weekly and monthly averages, and is compared to the observed and calculated values beginning in 1977.

Since each year begins on a different day of the week, the weekly historical Appendices C-1 to C-11 are standardized to begin each year on January 4. This allows for the same week comparison of each year. Because of this "Standard Week Ending" format, the year end sums will not match the corresponding years in summary Appendices A-1 to A-6.

Figures 1 and 2 illustrate 1992 to 1996 individual average ETP compared to long-term normal for Bakersfield. Figures 3 to 12 compare the Cotton and Fresno stations to the Bakersfield stations' Ep. All normal Ep in this report is based on established specific site normals. For example, Fresno's Ep when presented as "a percentage of normal" is compared to the Fresno site's historical reporting.

DISCUSSION OF EP FOR YEARS 1992 TO 1996

1992. The 1992 reported Ep for the Bakersfield station is an average of the measured value from the Bakersfield 12S and Lamont 2NW stations. Weekly data is tabulated in Table A-2. The Ep was 100.2 percent of normal as illustrated in Table B-2. Nearly all calculated crop ET rates were normal with the exception of dry beans, which was 95.6 percent of normal. The 1992 yearly total rainfall was 147.9 percent of the observed normal, even though many months during the growing season experienced below average rainfall and above normal temperatures.

More severe weather conditions were experienced at the Fresno State station, contributing to the 108.3 percent above average Ep and 106.4 percent of average Ep at the Cotton Field station, as illustrated by Figures 3 and 4.

1993. The 1993 reported Ep was an average of the observed measured values from Bakersfield 12S and Lamont 2NW. The Bakersfield stations measured only 96 percent of average and the Fresno State station measured 104.9 percent, as illustrated in Figure 6. The Cotton station measured only 98.5 percent of normal (Figure 5). Rainfall for the year was 142 percent of normal, heavily contributing to the lower or near normal evaporations experienced in the southern Valley. The calculated crop ET rates were at or below normal. Deciduous orchard (clean cultivated) was 95.9 percent, with field crops such as dry beans at 94 percent and cotton at 95 percent of normal ET as shown in Table B-3. This was probably a result of the 480 percent of normal rainfall for June and below normal temperatures that predominated much of the growing season.

1994. The Lamont 2NW station was removed in January 1994. In April an evaporation pan was established at Bakersfield 14W. This new site is approximately 30 miles west of the old site. The observed Ep and calculated crop ET rates were then determined using an average of Bakersfield 14W and 12S. We were not able to operate the Lamont 2NW and Bakersfield 14W stations concurrently and develop a ratio between the two. Consequently, no data was available to perform an analysis of concurrent readings.

The 1994 January to March Ep values for Bakersfield were estimated using long-term observed evaporation rates and ratios between the Lamont 2NW and the existing Bakersfield 12S evaporation pans. Bakersfield Ep was 103.4 percent of normal as illustrated in Figure 7 and Table B-4. This was peculiar due to the fact that precipitation was above average for the calendar year and temperatures were about normal. The higher evaporative demand may have been the result of a drier than normal period for the region during the 1993 – 1994 precipitation year (Oct. – Sept.), as reported by the National Weather Service in *California Crop Weather*, published by the USDA, California Agricultural Statistics Service.

Similar Ep was experienced at Fresno (Figure 8). The Cotton station Ep was 108 percent of normal as illustrated in Figure 7. Nonstandard site conditions likely contributed to the Cotton station's noticeably higher Ep.

Except for dry beans and vineyard, estimated crop ET as a percentage of normal approximated that of the pan evaporation curve. While dry beans were about equal to normal ET, vineyards totaled 10 percent more than normal ET, and cotton's estimated ET was about 4 percent above normal (Table B-4).

1995. The Bakersfield 12S station was removed in November 1995. Consequently, the November and December evaporation values were estimated based on the relationship between Bakersfield 12S and 14W. In the beginning of 1995, dry conditions occurred until the March rains, often referred to as the "Miracle March," which resulted in approximately 325 percent of normal precipitation. The trend continued into the months of April and May. Temperatures during this period remained below normal. Many agronomic problems were associated with these unseasonably late rains.

Beans were planted very late and cotton was replanted up to three times. Grapes were affected by the fungus *Botrytis*, and fungicide spraying costs soared for many other crops. The Ep for the Bakersfield area was 98.5 percent of normal (Figure 9 and Table B-5). The Cotton station was 98.7 percent of normal (Figure 9) and Fresno was 101.1 percent (Figure 10). The fact that the Bakersfield, Cotton, and Fresno stations' Ep, as a percentage of normal, was so similar for their respective regions illustrates how effectively the storms lowered Ep.

ET, when compared to normal for specific crops, was very dependent upon the time of season of the water use. Deciduous and other perennial crops' (such as alfalfa) annual ET as a percentage of normal approximated that of Ep. Other crops, such as cotton, ended the season with below normal ET, whereas the ET for grapes was slightly elevated primarily due to a leafout date that was two weeks earlier than normal.

1996. In 1996 unusually high temperatures contributed to a higher Ep demand, particularly during the latter part of June, all of July, and part of August. The above normal precipitation experienced in the spring resulted in some replanting of cotton. Fall rains arrived late and were heavier than normal.

These weather conditions led to an Ep of 106 percent of normal at the Bakersfield 14W station, and an Ep of 109 percent of normal at both the Fresno and Cotton stations (Figures 11 and 12). Consequently, all reported crops with the exception of dry beans experienced higher than normal ET (Table B-6).